PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) PROXIMITY DETECTION DEVICE

(71) I, RAYMOND NORMAN AUGER of 456 Riverside Drive, New York, New York, United States of America, a citizen of the United States of America, do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to fluidic proximity or object detectors employing fluid flow for detecting the presence of a surface or an object.

The detection of the presence of an object at a given position has been accomplished by various means in the prior art. As an example, photocells and lamp beam combinations, magnetic proximity switches and direct contact with a snap-action switch have been used. Also air gauging apparatus using back pressure signals wherein flow through an orifice is affected by an adjacent surface have been employed. All of these devices have various drawbacks.

According to the present invention there is provided a device for detecting the presence of an object, comprising a body having a nozzle for discharge of fluid fed under pressure to the body, the nozzle being arranged to produce a diverging peripheral stream of fluid the opposite sides of which converge subsequently due to the mutual attraction therebetween so as to envelope within said stream a region at a lower pressure than the pressure of fluid discharging from the nozzle, whereby introduction of an object to be detected into the stream disturbs the mutual attraction effect of at least part of the stream relative to the remainder of the stream to cause a change of pressure at a detection zone, and output means adjacent said detection zone for providing signals in accordance with the pressure at said detection zone and thereby indicate the presence of the object relative to the device.

The fluid outlet of the nozzle may be arranged in a continuous or discontinuous circle, square or other loop arranged to produce a stream which has a diverging annular or other tubular form extending around the periphery of the above mentioned lower pressure region prior to convergence of the opposite sides thereof.

The detection zone may be a zone at which the pressure changes from sub-atmospheric to above atmospheric when an object disturbs said mutual attraction effect. The detection zone may however be exterior of the path of the converging stream and the output means provided with a signal collecting orifice in the detection zone towards which flow from the nozzle is directed when an object disturbs the mutual attraction of portions of the stream, thereby causing an increase in pressure at the detection zone.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a fragmentary sectional view of one form of the invention;

Fig. 2 is a side view of the form shown in Fig. 1, the fluid flow pattern being schematically illustrated.

Fig. 3 is similar to Fig. 1 except that the output sensing passage is of a different form;

Fig. 4 is a graph showing the relation between the output pressure in tenths of an inch of water and the distance of the nozzle body from the surface or body being sensed;

Fig. 5 is a view of a modified form of Fig. 1;

Fig. 6 is a sectional view along the line 6—6 of Fig. 5;

Figs. 7, 8 and 9 are schematic diagrams showing uses of the invention;

Fig. 10 is a vertical sectional view of one form of the invention;

Fig. 11 is a top plan view of Fig. 10;

Fig. 12 is a vertical sectional view of another form of the invention;

Fig. 13 is a top plan view of Fig. 12;

Fig. 14 is a fragmentary view of another form of the invention;

Fig. 15 is a top plan view of Fig. 14;

Fig. 16 is a vertical sectional view of still another form of the invention;

Fig. 17 is a top plan view of Fig. 16;

Fig. 18 is a top view of still a further form of the invention;

Figs. 19 and 20 are fragmentary vertical sections of Fig. 18 taken along the lines 19—19 and 20—20 respectively;

Fig. 21 is the top view of a further modification of the invention; and

Figs. 22 and 23 are fragmentary vertical sections of Fig. 21 taken along the lines 22—22 and 23—23 respectively.

One form of the invention is illustrated in Figs. 1 and 2 wherein body 10 has a passage 11 connected to an air or fluid supply at 12. At the outlet or nozzle end 13, there is located a conically shaped member 14 which will direct the fluid flow in a conical annular jet or path 15. An output signal passage 16 in member 14 communicates with the zone encircled by jet 15, and passage 16 is connected through 17 to any suitable signal sensing or receiving apparatus, for example an indicating mechanism or an alarm arrangement. In operation, the jet assumes the flow pattern shown in Fig. 2. When a body or surface is placed in a close or predetermined proximity to the nozzle end 13, the jet 15 assumes a different flow pattern which causes a change in pressure in the signal passage 16.

It can be theorized that, in the flow pattern existing in the absence of any body or surface adjacent the nozzle end 13, there is an entrainment of air within the conical jet which causes the air to bend inward. Inward movement prevents atmospheric flow from relieving the sub-atmospheric pressure which develops within the cone so that a "bubble" is formed with a "skin" of high velocity flow maintaining a sub-atmospheric center. If the bubble is stressed by a body or surface, it bursts abruptly. As the upward flow impinges on a surface, the flow pattern is changed at a predetermined point of distance therefrom.

The angle R of the jet can range from about 25° to 50° relative to axis 18. If the angle R is too great, there is little or no mutual attraction between opposite sides of the jet which therefore remains conical. If R is to small, the pattern shown in Fig. 2 will remain even when an object is adjacent the nozzle end 13. Among the factors affecting the flow pattern are the location of the output passages relative to the flow and the overall configuration in the vicinity of the nozzle. Merely by way of example, a device as illustrated in Fig. 1 with a conical member having a maximum diameter of 0.140 inches produced the results shown in Fig. 4 in which the ordinate scale represents the signal pressure in passage 16 in tenths of an inch of water, the abscissa scale represents the distance in tenths of an inch of an object from the outer end of the member 14, the letters PSI represent pounds per square inch, and the letters CFH represent cubic feet per hour. As shown in Figure 4, the output pressure switched from positive to negative, that is from above atmospheric pressure to below atmospheric pressure when the object was at a distance of 0.25 inches from the device over a range of supply pressures from 1 to 6 pounds per square inch. The switching differential, that is the range within which switching took place from negative to positive pressure, was only 0.006 inches. Thus it is seen that the device is a bistable detector, that is a detector which switches between two stable positions when the object to be detected is moved through a predetermined position relative to the device.

As an example, and again referring to Fig. 4, a supply consumption of 15 cubic feet per hour by a nozzle 0.140 inches in diameter will give a signal pressure of somewhat greater than 0.1 inch of water. Such a level is adequate to operate a turbulence amplifier or other amplifier.

The arrangement seen in Fig. 3 is similar to Fig. 1 wherein body 19 has a supply passage 20 and an annular jet 21. Conical member 22, however, has a "set-back" surface 23 with output passages 24 connected to output passage 25. The output of the device of Fig. 3 is the relatively low pressure occurring at the edge 26 of the cone due to entrainment of air by air at this location. The set-back of portion 23 causes a greater reduction of pressure than would be the case if there was no set-back portion.

In a still further form, as illustrated in Figs. 5 and 6, body 30 has inlet or supply passage 31 and conical member 32. Conical member 32 is carried on output tube 33 which has a collar 34 thereon. Collar 34 is adjustably positioned in passage 35 by means of screws 36 so that conical member 32 can be eccentrically located relative to the mating walls 37 of the body 30, tube 33 having sufficient flexibility for this purpose.

The flow pattern of the jet 38 will be deflected so that the widest portion 39 of the jet will dominate the narrower portion 40 causing the direction of total flow to be deflected in favour of the direction of the widest portion of the stream. Such will cause the narrow portion of the annular stream to change direction, e.g., on the order of 90°, and to pass near the setback at the point of the orifice 41 of the output passage 33. It will create at this point the lowest pressure around the entire periphery of the cone. A disruption of the bubble then will cause the jet to take a conic shape and to change markedly the pressure at the orifice 41.

The use of the offset of eccentric nozzle of Figs. 5 and 6 will result in an increase of output signal up to a factor of 10 over that of Figs. 1 and 3.

Referring now to Fig. 7, the arrangement can be used to connect with a conventional

spring biased valve means. The output of the proximity sensor described herein is connected to line 50, the valve being illustrated schematically at 51. The valve, for example, may be a valve which is operated by a diaphragm 52 by connection or link 53. Diaphragm 52 is held in chamber 53A in which there is a spring 54 biasing the diaphragm in a dircetion toward the valve as seen in Fig. 7. When the normally negative pressure of the proximity sensor is applied to line 50 and is changed to a positive pressure, the diaphragm will under the influence of spring 54 move downwardly. Thus, there will be a control combination of the bistable proximity sensor to operate a valve which will provide a means of utilizing the relatively low control pressures involved in the proximity sensor to provide a relatively high working pressure.

Referring now to Fig. 8, the input from the proximity sensor is connected through line 55 to a conventional pressure switch 56. Pressure switch 56 may have vacuum applied thereto by a conventional aspirator or jet pump schematically shown at 57, the supply pressure of which is fed thereto at 58 and the exhaust is seen at 59. The aspirator provides a vacuum through line 60 to the pressure switch 56. By the use of this arrangement there is provided a subatmospheric reference pressure to the pressure switch of Fig. 8.

Referring now to Fig. 9, a tubulence or other type of fluidic amplifier is schematically shown at 61 such as it known in the art. The output of the turbulence amplifier is indicated at 62 and it is exhausted to the atmosphere at 63. The exhaust to the atmosphere is connected in this arrangement to an aspirator 64 to provide a subatmospheric reference pressure. The output signal of the proximity sensor is connected through line 65 to the turbulence amplifier or other fluidic amplifier. This arrangement thus operates with a subatmospheric signal and a subatmospheric reference pressure.

A still further form is seen in Fig. 10 in which body 120 of suitable material has a plurality of holes 121 leading from the input pressure passage 122 to the cylindrical passage 123. The cylindrical-like passage is formed by the offset cylinder 124 adjustably held in position by screw 125 on bridge 126 or other similar means. The left side 127 (Figs. 10, 11) of passage 123 is wider than the right side 128 (Figs. 10, 11) of said passage 123. Signal sensing slot 129 is fastened to body 120 by screws 130. The signal sensing slot or collection means 129 is connected by passage 131 to signal passage 132.

As fluid flow or jet exits from the nozzle, it follows surface 133 because of the coanda effect forming a vortex at 134.

The narrow part of the stream from side 128 is deflected towards the thicker part flowing from side 127. The presence of an object in the center of the converging stream causes at least a portion of the narrow part of the stream to deflect, so that only part of the stream is collected by the sensing means at collection slot 135 which is adjacent the outside of the annular-like jet. The collection slot 135 which acquires the deflected flow of the deflected portion of the stream as shown in Fig. 11 indicates that only about 10° to 20° of the stream is collected thereby. Air flow or pressure observed at slot 135 is transmitted by the passages 131, 132 to the port 137 at the base of the unit. Presence of an object adjacent to the jet will change the flow which will provide bistable signal characteristics.

Another form is seen in Figs. 12 and 13 wherein body 136 has a main inlet port 137 directing fluid flow through holes 138 in the nozzles center structure. Cylindrical member 139 extends upwardly from base 140, the upper portion 141 being offset or eccentric relative to passage 142. Because of the coanda effect, the flow through portion 143 of the passage will follow the surface 144 of the cylindrical portion 141. On the other side of the nozzle, the narrower portion 145 causes the flow therethrough to stick to surface 146 and to follow around the bevel face 147 when the annular-like jet is not deflected by an object, and then enter collection slot 148 when an object causes deflection of the annular-like jet. The collected pressure at 148 will affect pressure in signal passage 149. The collection or signal sensing means at 150 is adjacent the exterior of the annular-like fluid flow jet stream.

A still further form is seen in Figs. 14 and 15 wherein body 151 has fluid fed thereto through passage 152. Plug 153 has a series of inclined passages 154 therearound. The apertures do not necessarily need to be of the same diameter or spacing nor does the angle of divergency have to be the same. The apertures also could be oblong, square, rectangular, etc. The signal collector 155 has a signal passage 156 similar to the previous forms. The passages 154 can be formed to provide a wider portion at the lefthand side (Fig. 14) of the jet and at a smaller angle to the vertical or longitudinal axis as compared to the righthand (Fig. 14) side. The flow through the apertures will produce an annular-like jet which will join as it recedes from the nozzle and which will be deflected by the proximity of an object.

Figs. 16 and 17 show still a further arrangement of the invention. Body 157 has a center cone 158 with the fluid input connection at 159.

The power stream coming up from the power inlet connection at 159 through aperture 159A hugs the surface of the semisphere 158 and enters the atmosphere with a tubular shape. There will be some stream attraction,

giving the stream a focused tendency and a subatmospheric center, which, entering the ports 160 will cause a subatmospheric center at annular control slot 161. When an object breaks into the projected stream such as to raise the pressure in the center thereof, the rise in pressure will lessen the attraction of the power stream by the semisphere because of the rise in pressure at the slot 161. The stream tends to separate from the semisphere 158 rather than follow it to its lip 162, and consequently, part of the deflected stream now enters annular slot 163. A passage 164 from slot 163 carries the change in pressure resulting from the deflection of the power stream to an output port 165. The annular slot 166 is connected to the atmosphere by passages 167 which minimizes the tendency of the stream to stick to the surfaces 168, 169.

The rise in pressure at ports 160 when an object breaks into the projected stream causes air to flow through ports 160, 161 to augment the air entering at 159, and thereby achieves an amplifying effect on the signal output at port 165. It should be apparent that some of the holes 160 can be omitted in any part of structure at which additional air is not required. Furthermore, it could be made so that the structure of Figs. 16 and 17 might be hexagonal or square.

Variations of the structure illustrated in Figs. 16 and 17 can be made to create special effects. For example, atmospheric vent passage 167 can be connected to a source of subatmospheric or above atmospheric pressure to make the unit bistable, under one set of conditions, or to keep it from becoming bistable, under another set of conditions.

In the form shown in Figs. 18, 19 and 20, body 170 has a central portion 171 supported on central member 172. The central member 171 is offset so as to provide a slot 173 which is wider than the slots at 174 and 175. Collection or signal sensing member 176 is similar to and operates in a manner following that of the previously described forms. The jet 177 is tubular in form following generally that previously described.

A parallel slot arrangement is depicted in Figs. 21, 22 and 23 wherein body 178 has a central portion 179. Slot 180 is wider than slot 181. The slot 181 is angled at the center portion 182 thereof as compared to the slot configuration either side thereof. Fluid passing through input 183 will be deflected outwardly at 184 and combines with the flow at 186 to form a tubular jet at 185.

As the jet flow recedes from the sensor the opposite sides of the jet will tend to come together. Upon deflection thereof by the presence of an object, a signal will be collected by the signal sensing means 187 in a manner similar to the previously described devices.

WHAT I CLAIM IS:—

1. A device for detecting the presence of an object, comprising a body having a nozzle for discharge of fluid fed under pressure to the body, the nozzle being arranged to produce a diverging peripheral stream of fluid the opposite sides of which converge subsequently due to the mutual attraction therebetween so as to envelope within said stream a region at a lower pressure than the pressure of fluid discharging from the nozzle, whereby introduction of an object to be detected into the stream disturbs the mutual attraction effect of at least part of the stream relative to the remainder of the stream to cause a change of pressure at a detection zone, and output means adjacent said detection zone for providing signals in accordance with the pressure at said detection zone and thereby indicate the presence of the object relative to the device.

2. A device according to claim 1, wherein the pressure at said detection zone changes from sub-atmospheric to above atmospheric pressure when an object disturbs said mutual attraction effect.

3. A device according to claim 1 or 2, wherein the nozzle comprises a conical opening in the body and a conically shaped member co-operates with said opening to produce a conical annular stream of fluid when the nozzle is fed with fluid under pressure.

4. A device according to claim 3, wherein the conical opening and the conically shaped member are eccentric relative to each other.

5. A device according to claim 4, including means to adjust the eccentricity of the opening and conically shaped member.

6. A device according to claim 2, 3 or 4 wherein the conically shaped member has a set-back face portion and the output means communicate with the detection zone at said face portion.

7. A device according to any of the preceding claims, including control means operable by signals received from said output means, and means for subjecting the control means to sub-atmospheric pressure so as to bia the control mean toward one control setting.

8. A device according to claim 7, wherein the control means comprises a valve actuated by a spring biased diaphragm.

9. A device according to any of claims 1—6, including a fluidic amplifier operable by signals received from said output means.

10. A device according to claim 9, wherein said amplifier is a fluidic tubulence amplifier.

11. A device according to claim 10, including means for subjecting the turbulence amplifier to a sub-atmospheric pressure source to provide a reference pressure therefor.

12. A device according to Claim 1, wherein the detection zone is exterior of the path of the converging stream and the output means

has a signal collecting orifice in said detection zone towards which flow from the nozzle is directed when an object disturbs the mutual attraction of portions of the stream thereby causing an increase in pressure at the detection zone.

13. A device according to claim 12, wherein the nozzle comprises an opening in the body and a central member offset in said opening for producing a fluid flow peripheral stream which has relatively thin and wide flow portions.

14. A device according to claim 13, wherein the signal collecting orifice is located in a restricted area adjacent the thinner portion of the output fluid flow stream.

15. A device according to claim 13 or 15, wherein the central member has a bevelled upper face.

16. A device according to claim 12, 13 or 14, wherein the nozzle comprises an opening in the body and a central member is said opening, said central member having a substantially part-spherical undersurface.

17. A device according to claim 16, wherein the central member has passages leading from its outer surface to passages between the central member and a wall of said opening.

18. A device according to claim 17 wherein the body is provided with connection passage means between the exterior of the body and the passage between the central member and the wall of said opening.

19. A device according to claim 12, wherein the nozzle comprises a plurality cf apertures in the body.

20. A device according to claim 19, wherein the apertures are arranged to provide a peripheral fluid stream in which the side adjacent the signal collecting orifice is thinner than the opposite side.

21. A device according to claim 13, wherein the central member is substantially rectangular in shape.

22. A device according to claim 13, wherein the central member co-operates with the opening in the body one wide slot and one narrower slot, the narrower slot being adjacent the signal collecting orifice.

23. A device according to claim 13, wherein the central member co-operates with the opening in the body to provide a relatively narrow slot adjacent the signal collecting orifice and a relatively wide slot on the side of the central member remote from said orifice.

24. An object detecting device substantially as hereinbefore described with reference to Figures 1 and 2, or Figure 3, or any of Figures 5—23.

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1239431 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

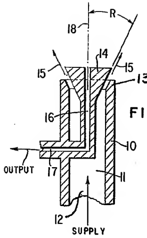


FIG.1

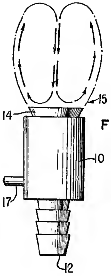


FIG.2

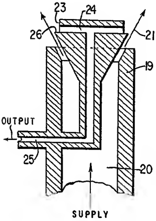


FIG.3

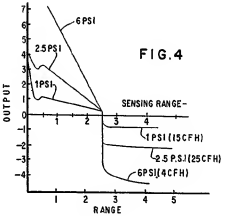


FIG.4

FIG.5

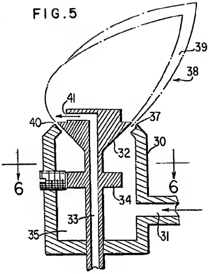
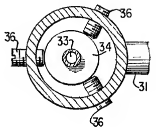


FIG.6



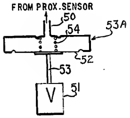
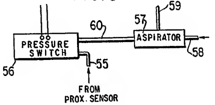


FIG.7

FIG.8



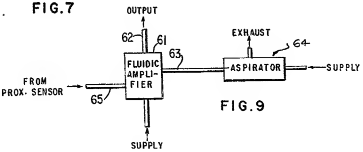


FIG.9

1239431 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

FIG.11

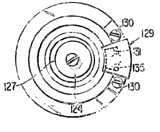
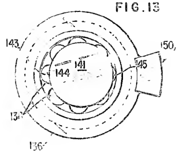


FIG.13



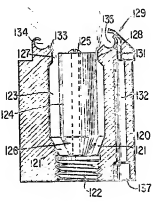


FIG.10

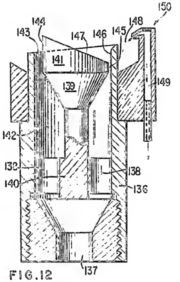


FIG.12

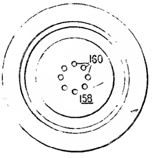
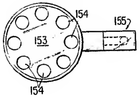


FIG.17

FIG.15



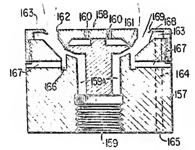


FIG.16

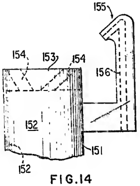


FIG.14

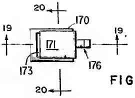


FIG.18

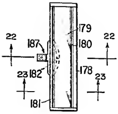


FIG.21

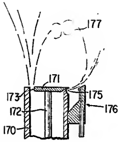


FIG.19

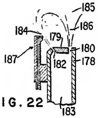


FIG.22

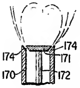


FIG.20

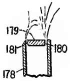


FIG.23